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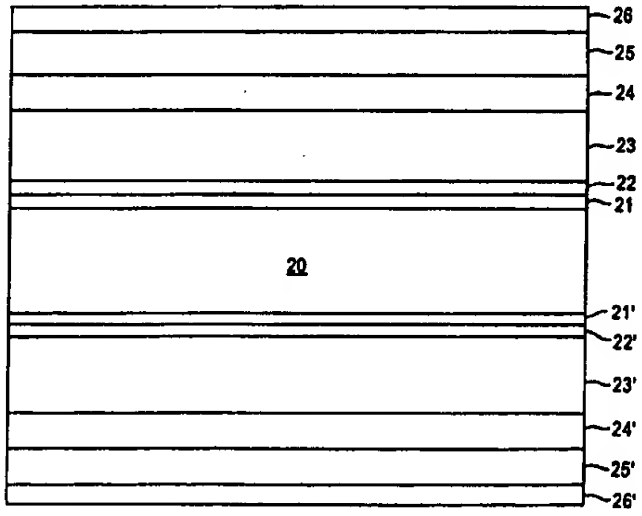

(57) Abstract

Magnetic recording media exhibiting improved Hr, SNR and S*, suitable for high area recording density, are obtained by forming a substantially uniform patterned Al or Al alloy layer (21, 21') on a non-magnetic substrate (20) which is substantially replicated in subsequently applied layers (22, 22', 23, 23', 24, 24', 25, 25', 26, 26') to form a data zone. Embodiments include sputtering depositing an Al or Al alloy layer (21, 21') on the substrate (20) and anodizing the sputtered layer (21, 21') to form a plurality of substantially uniform hexagonal cells comprising aluminum oxide. The hexagonal pattern is replicated in a subsequently deposited and epitaxially grown magnetic layer (24, 24') such that the magnetic grains are separated, thereby reducing magnetostatic interactions therebetween.

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MAGNETIC RECORDING MEDIUM WITH PATTERNED SUBSTRATE

Related Application

This application claims priority from provisional patent application Serial No. 60/074,253 filed, February 10, 1998, entitled "PATTERN SUBSTRATE FOR HIGH COERCIVITY AND LOW NOISE MEDIA", the entire disclosure of which is hereby incorporated herein by reference.

Technical Field

The present invention relates to the recording, storage and reading of magnetic data, particularly rotatable magnetic recording media, such as thin film magnetic disks having textured surfaces for contact with cooperating magnetic transducing heads. The invention has particular applicability to high density magnetic recording media exhibiting low noise, reduced flying heights and high coercivity.

Background Art

Magnetic disks and disk drives are conventionally employed for storing data in magnetizable form. Typically, one or more disks are rotated on a central axis in combination with data transducing heads positioned in close proximity to the recording surfaces of the disks and moved generally radially with respect thereto. Magnetic disks are usually housed in a magnetic disk unit in a stationary state with a magnetic head having a specific load elastically in contact with and pressed against the surface of the disk. It is extremely difficult to produce a magnetic recording medium for ultra-high density recording having suitable magnetic properties, such as high coercivity, e.g., greater than 2500 Oersteads, and a high overwrite, e.g., about 40dB, while at the same time exhibiting suitable mechanical properties for read-write performance, such as a small glide height avalanche, e.g., about 0.75 to about 0.85 μ inch.

In operation, the magnetic disk is normally driven by the contact start stop (CSS) method, wherein the head begins

to slide against the surface of the disk as the disk begins to rotate. Upon reaching a predetermined high rotational speed, the head floats in air at a predetermined distance from the surface of the disk due to dynamic pressure effects caused by the air flow generated between the sliding surface of the head and the disk. During reading and recording operations, the transducing head is maintained at a controlled distance from the recording surface, supported on a bearing of air as the disk rotates. The magnetic head unit is arranged such that the head can be freely moved in both the circumferential and radial directions of the disk in this floating state allowing data to be recorded on and retrieved from the surface of the disk at a desired position.

Upon terminating operation of the disk drive, the rotational speed of the disk decreases and the head begins to slide against the surface of the disk again and eventually stops in contact with and pressing against the disk. Thus, the transducing head contacts the recording surface whenever the disk is stationary, accelerated from a stop and during deceleration just prior to completely stopping. Each time the head and disk assembly is driven, the sliding surface of the head repeats the cyclic operation consisting of stopping, sliding against the surface of the disk, floating in the air, sliding against the surface of the disk and stopping.

It is considered desirable during reading and recording operations to maintain each transducing head as close to its associated recording surface as possible, i.e., to minimize the flying height of the head. This objective becomes particularly significant as the areal recording density increases. The areal density (Mbits/in^2) is the recording density per unit area and is equal to the track density (TPI) in terms of tracks per inch times (x) the linear density (BPI) in terms of bits per inch. Thus, a smooth recording surface is preferred, as well as a smooth opposing surface of the associated transducing head, thereby permitting the head and the disk to be positioned in closer proximity with an attendant increase in predictability and consistent behavior

of the air bearing supporting the head. However, another factor operates against this objective. If the head surface and recording surface are too flat, the precision match of these surfaces gives rise to excessive stiction and friction during the start up and stopping phases, thereby causing wear to the head and recording surfaces eventually leading to what is referred to as a "head crash." Thus, there are competing goals of reduced head/disk friction and minimum transducer flying height.

In order to satisfy these competing objectives, the recording surfaces of magnetic disks are conventionally provided with a roughened surface to reduce the head/disk friction by techniques referred to as "texturing." Conventional texturing techniques involve polishing the surface of a disk substrate to provide a texture thereon prior to subsequent deposition of coatings, such as an underlayer, magnetic layer, carbon overcoat and lubricant topcoat, wherein the textured surface on the substrate is reproduced on the surface of the magnetic disk.

A typical longitudinal recording medium is depicted in Fig. 1 and comprises a substrate 10, typically aluminum (Al) or an Al alloy, such as an aluminum-magnesium (Al-Mg) -alloy, plated with a layer of amorphous nickel-phosphorus (NiP). Alternative substrates include glass, ceramic, glass-ceramic materials and graphite. Substrate 10 typically contains sequentially deposited on each side thereof a chromium (Cr) or Cr-alloy underlayer 11, 11', a cobalt (Co) base alloy magnetic layer 12, 12', a protective overcoat 13, 13', typically containing carbon, and a lubricant topcoat 14, 14'. Cr underlayer 11, 11' can be applied as a composite comprising a plurality of sub-underlayers 11A, 11A'. Cr underlayer 11, 11', Co base magnetic alloy layer 12, 12' and protective overcoat 13, 13' are typically sputter deposited in an apparatus containing sequential deposition chambers. A conventional Al-alloy substrate is provided with a NiP plating, primarily to increase the hardness of the Al substrate, serving as a suitable surface to provide a texture,

which is substantially reproduced on the disk surface to serve as a landing zone.

Increasingly high density and large-capacity magnetic disks require smaller flying heights, i.e., the distance by which the head floats above the surface of the disk in the CSS drive. The requirement to further reduce the flying height of the head imposed by increasingly higher recording density and capacity render it particularly difficult to accurately control texturing to avoid head crash.

Conventional techniques for providing a disk substrate with a textured surface comprise a mechanical operation, such as polishing. See, for example, Nakamura et al., U.S. Patent No. 5,202,810. Conventional mechanical texturing techniques are attendant with numerous disadvantages. For example, it is extremely difficult to provide a clean textured surface due to debris formed by mechanical abrasions. Moreover, the surface inevitably becomes scratched during mechanical operations, which contributes to poor glide characteristics and higher defects. In addition, various desirable substrates are difficult to process by mechanical texturing. This undesirably limiting facet of mechanical texturing, virtually excludes the use of many inexpensive substrates as well as conductive graphite substrates which facilitate achieving high coercivities.

An alternative to mechanical texturing involves the use of lasers to form a landing zone. See, for example, Ranjan et al., U.S. Patent No. 5,062,021. Another alternative to mechanical texturing is disclosed by Lal et al., U.S. Patent No. 5,166,006, and involves chemical etching.

In copending U.S. Patent Application Serial No. 08/608,072 filed on February 28, 1996, a magnetic recording medium is disclosed which has a textured surface formed by sputtering a metallic layer, such as titanium or a titanium alloy, on a non-magnetic substrate, inclusive of a glass, glass-ceramics materials and NiP chemically plated Al-Mg alloy substrates. It has, however, been found difficult to produce a magnetic recording medium having a suitably high coercivity

greater than 2500 Oersteads, such as greater than 3000 Oersteads, particularly greater than 3300 Oersteads, with a sputter textured layer. In addition, since the topography of the sputtered layer is greatly dependent upon the underlying layer, on which it is deposited, e.g., substrate, process parameters must be optimized for each different type of underlying material, thereby decreasing production throughput. Without such optimization of process parameters, consistently reproducible results are difficult to achieve.

The requirements for high areal recording density impose increasingly greater requirements on thin film magnetic recording media in terms of coercivity, remanent squareness, low medium noise and narrow track recording performance. It is extremely difficult to produce a magnetic recording medium satisfying such demanding requirements, particularly a high density magnetic rigid disk medium for longitudinal recording.

The linear recording density can be increased by increasing the coercivity of the magnetic recording medium. However, this objective can only be accomplished by decreasing the medium noise, as by maintaining very fine magnetically noncoupled grains. Medium noise is a dominant factor restricting increased recording density of high density magnetic hard disk drives. Medium noise in thin films is attributed primarily to inhomogeneous grain size and intergranular exchange coupling. Therefore, in order to increase linear density, medium noise must be minimized by suitable microstructure control.

It is recognized that the relevant magnetic properties, such as remanent coercivity (Hr), magnetic remanence (Mr) and coercive squareness (S*), which are critical to the performance of a magnetic alloy thin film, depend primarily on the microstructure of the magnetic layer which, in turn, is influenced by the underlayer on which it is deposited. Conventional underlayers include Cr, molybdenum (Mo), tungsten (W), titanium (Ti), chromium-vanadium (CrV) as well as Cr alloyed with various substitutional elements. It is recognized that underlayers having a fine grain structure are

highly desirable, particularly for growing fine grains of hexagonal close packed (HCP) magnetic Co or Co alloy layers deposited thereon.

In order to satisfy the ever increasing needs for high data storage capacity, it is necessary to manufacture magnetic recording media exhibiting higher Hr and lower media noise i.e., high SNR. Higher Hr effectively narrows the PW50 (pulse width at half maximum) and enables a reduction in the bit length for higher recording density. Micromagnetic studies have been conducted over the past several years to increase Hr and reduce media noise. It is recognized that Hr increases and media noise decreases when magnetic grain interactions are reduced. Since media noise predominately arises from exchange and magnetostatic interactions among magnetic grains, an effective way to suppress such factors is to separate the magnetic grains either physically or chemically, i.e., segregate. Earlier efforts by researchers in this area have concentrated primarily on the magnetic layer and the underlayers. However, there are limits as to the manner in which such underlayer and magnetic layer can be grown.

In the past, substrate treatment or substrate related approaches to ultimately separate or segregate the magnetic grains to reduce exchange and magnetostatic interactions for increasing Hr have not received significant attention. For example, prior efforts in this area have involved high precision photolithographic techniques, which are extremely time consuming and expensive. Accordingly, large volume production is virtually impossible.

Co-pending application Serial No. 08/699,759, filed on August 20, 1996, discloses that Cr films deposited on surface oxidized NiP layers experience smaller grains than Cr films deposited on non-oxidized NiP layers. Co-pending application Serial No. 08/586,529, filed on January 16, 1996, discloses a method of depositing Cr films on surface oxidized NiP films, wherein the deposited Cr films exhibit a (200) -dominant crystallographic orientation.

In co-pending Application Serial No. 08/945,084 filed on October 17, 1997 (Our Docket No. 2674-052; 50103-092), a magnetic recording medium having high coercivity is disclosed, which magnetic recording medium comprises a seedlayer having an oxidized surface formed on a non-magnetic substrate, a chromium-containing sub-underlayer on the oxidized surface of the seedlayer, a nickel-aluminum or iron-aluminum underlayer, a chromium-containing intermediate layer on the underlayer and a magnetic layer on the intermediate layer.

Co-pending Application Serial No. 09/043,610 filed on March 19, 1998 (Our Docket No. 2674-057; 50103-098) discloses a magnetic recording medium comprising a sputter textured layer.

In co-pending applications Serial Nos. 08/972,229 filed on November 17, 1997 (Our Docket No. 2674-072; 50103-118) and Serial No. 08/955,448 filed on October 21, 1997 (Our Docket No. 2674-073; 50103-119), methods are disclosed for employing a laser beam to texture a data zone.

U.S. Patent No. 5,470,636, issued to Wakui et al. on November 28, 1995, discloses the formation of a landing zone by anodizing an Al substrate or Al layer on a substrate, filing the resulting pores with a non-magnetic material extending above the anodized surface and treating the anodized layer with a fluorine reagent, acid or base.

There exists a continuing need for magnetic recording media suitable for high areal recording density exhibiting high Hr, high SNR and high S* and improved flying characteristics. There also exists a continuing need for cost effective, efficient methodology for manufacturing high areal density magnetic recording media exhibiting high Hr, SNR and S* and improved flying characteristics.

Disclosure of the Invention

An advantage of the present invention is a magnetic recording medium suitable for high areal density longitudinal magnetic recording which exhibits low medium noise, high Hr, high S* and improved flying characteristics.

Another advantage of the present invention is a cost effective, efficient method of manufacturing a magnetic recording medium suitable for high areal density longitudinal magnetic recording which exhibits low medium noise, high Hr, high S* and improved flying characteristics.

Additional advantages and other features of the present invention will be set forth in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from the practice of the present invention. The advantages of the present invention may be realized and obtained as particularly pointed out in the appended claims.

According to the present invention, the foregoing and other advantages are achieved in part by a magnetic recording medium comprising: a non-magnetic substrate; a layer comprising Al or an Al alloy on the substrate, the Al or Al alloy having a substantially uniform pattern thereon; and a magnetic layer; wherein, the pattern is substantially replicated on the magnetic layer to form a data zone.

Another aspect of the present invention is a method of manufacturing a magnetic recording medium, the method comprising: forming a layer of Al or an Al alloy on a non-magnetic substrate; forming a substantially uniform pattern on the Al or Al alloy layer; and forming a magnetic layer; wherein, the pattern is substantially replicated on the magnetic layer to form a data zone.

Embodiments of the present invention comprise anodizing the Al or Al alloy layer to form a substantially uniform honeycomb pattern comprising substantially hexagonal cells of Al oxide. Embodiments of the present invention further comprise texturing the surface of the substrate to form a textured area which is substantially replicated on subsequently deposited layers, including the magnetic layer, to form a recording data zone.

Additional advantages of the present invention will become readily apparent to those skilled in this art from the following detailed description, wherein the embodiments of the

present invention are described, simply by way of illustration of the best mode contemplated for carrying out the present invention. As will be realized, the present invention is capable of other and different embodiments, and its several details are capable of modifications in various obvious respects, all without departing from the present invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

Brief Description of Drawings

Fig. 1 schematically depicts a conventional magnetic recording medium structure.

Fig. 2 schematically depicts a magnetic recording medium structure in accordance with the present invention.

Fig. 3 is an atomic force microscope (AFM) image of a NiP/Al substrate before and after anodizing in accordance with an embodiment of the present invention.

Figs. 4A and 4B show the Hr and SNR, respectively, of an embodiment of the present invention vis-à-vis a conventional magnetic recording medium.

Description of the Invention

The present invention addresses the problem of increasing the data storage capacity of magnetic recording media by increasing the Hr and lowering media noise. The increased Hr narrows the pulse width and enables a reduction of the bit length for increased recording density. Lower media noise generates a higher SNR. Embodiments of the present invention achieve the foregoing objectives by a physically segregating the magnetic grains of the magnetic layer. Such physical segregation of magnetic grains is achieved by forming a pattern on the substrate which initiates magnetic film growth in patterns. Such patterns minimize the irregularity of grain growth and narrow the magnetic grain unit's distribution, thereby reducing the origins of zigzag transitions, consequently suppressing magnetic grain interactions and improving SNR.

Embodiments of the present invention comprise forming a continuous film on any of various conventional non-magnetic substrates. The continuous film is patterned to provide a substantially uniform matrix for thin film growth, which matrix is substantially replicated in subsequently deposited layers, including the magnetic layer, to form a data zone. In other words, the uniform pattern formed on the substrate in accordance with embodiments of the present invention serves as a template for films subsequently deposited thereon, e.g. the underlayer and magnetic layer. Thus, magnetic unit clusters are replicated in accordance with the substrate pattern and, hence, magnetic grain clusters are separated by the pattern boundaries. In this way, grain interactions are minimized and SNR increased.

In accordance with embodiments of the present invention, an Al or Al alloy is sputter deposited on a non-magnetic substrate, such as a NiP plated Al or Al alloy substrate, or a glass, ceramic, or glass-ceramic substrate. The Al or Al alloy film can be sputter deposited to a thickness of about 50Å to about 5000Å, e.g., about 500Å to about 1500Å. In accordance with embodiments of the present invention, a substantially uniform pattern is formed on the sputter deposited Al or Al alloy film to serve as a template such that the magnetic grain clusters of the subsequently deposited magnetic layer are separated by the pattern boundaries. The sputter deposited Al or Al alloy film is anodized to form a pattern comprising aluminum oxide, such as a substantially honeycomb pattern. Anodization can be effected in any conventional manner, as by treatment with a solution of hydrogen phosphate (H_3PO_4) of about 1% to about 10%, e.g. about 4%, at about 1 to about 15mA/cm^2, e.g. about 5mA/cm^2, at room temperature for up to about 1 hour, e.g. about 10 minutes. The resulting substantially honeycomb pattern comprises substantially hexagonal cells of aluminum oxide. Such substantially hexagonal cells serve as a suitable template for the subsequently deposited magnetic layer such that epitaxial growth is effective to produce a desired

hexagonal close packed (HCP) crystal structure. Moreover, the boundaries of the substantially hexagonal cells, due to substantial replication in the magnetic layer, serve to separate the magnetic grain clusters thereby minimizing grain interactions and improving SNR.

Subsequent to anodization, the magnetic recording medium is completed by depositing an underlayer and magnetic layer on the anodized surface, replicating the patterns on the substrate. For example, a seedlayer, such as nickel aluminum (NiAl) is deposited on the anodized Al or Al alloy layer. It is believed that the cells are not completely filled. An underlayer, such as CrV, is sputter deposited on the NiAl seedlayer, and a magnetic layer, such as a cobalt-chromium-platinum-tantalum (CoCrPtTa) alloy layer is sputter deposited on the underlayer. A protective overcoat, such as a carbon-containing protective overcoat, is sputter deposited on the magnetic layer and a lubricant topcoat is formed on the protective overcoat. The layers can be sputter deposited in order to optimize magnetic properties, as by employing a base pressure of 2×10^{-7} Torr with a substrate temperature of about 200°C to 300°C and a substrate bias at about -250 volts, employing a sputtering power density of between $2W/cm^2$ to $30W/cm^2$ utilizing a sputtering gas flow rate of about 15 sccm.

An embodiment of the present invention is schematically illustrated in Fig. 2 and comprises a non-magnetic substrate 20, such as NiP plated Al. On each side of substrate 20 is sequentially formed an anodized sputter deposited Al layer 21, 21' comprising a substantially uniform honeycomb pattern of substantially hexagonal cells of aluminum oxide. Seedlayer 22, 22', such as NiAl, is sputter deposited on the honeycomb pattern. An underlayer 23, 23', such as CrV, is sputter deposited on seedlayer 22, 22', and a magnetic layer 24, 24', such as CoCrPtTa, is sputter deposited on underlayer 23, 23'. During epitaxial growth, an HCP pattern is formed substantially following the template of the patterned layer 21, 21', such that the patterned boundaries separate the magnetic grain clusters, thereby minimizing grain interactions

and improving SNR. A conventional protective overcoat 25, 25', such as a carbon-containing protective overcoat, is sputter deposited on the magnetic layer 24, 24' and a conventional lubricant topcoat 26, 26' formed thereon.

Example

A magnetic recording medium in accordance with the present invention was made by sputter depositing an Al layer on an NiP/Al substrate and anodizing the Al layer to form a substantially honeycomb Al oxide pattern comprising substantially hexagonal cells having a depth of about 500Å and a diameter of about 500Å, suitable for magnetic recording bit size scales. A NiAl seedlayer was deposited on the anodized Al layer, a CrV underlayer was deposited on the NiAl seedlayer, and a CoCrPtTa magnetic layer was deposited on the CrV underlayer. A carbon-containing protective overcoat was deposited on the CoCrPtTa layer. The Al layer was anodized in a 4% H_3PO_4 solution and the results of anodization are shown in Fig. 3, the left hand portion of Fig. 3 illustrating the Al layer before anodization and right hand portion comprising the honeycomb structure subsequent to anodization.

A comparison (regular) magnetic recording medium was made employing substantially the same layers and substantially the same deposition conditions as in forming the magnetic recording medium representative of the present invention, except that an Al layer was not sputter deposited on the substrate and anodized. The magnetic properties of both media were tested employing a non-destructive rotating disk magnetometer. Recording characteristics and media noise was measured at a linear density of 240kfci (kiloflux changes per inch) employing a Guzik 1601 tester with a magnetorestive (MR) head having a 0.35 μin gap length and flying at a nominal height of 2.1 μin.

The test results are depicted in Figs. 4A and 4B. Fig. 4A shows the magnetic properties of the comparison (regular) medium and the medium in accordance with the present invention (patterned sub). It is apparent from Fig. 4A that the use of

a pattern Al layer on the substrate resulted in an increase in Hr.

Fig. 4B illustrates that the magnetic recording medium in accordance with the present invention exhibits an improvement in SNR of about 0.5 to about 1dB vis-à-vis the comparison (regular) magnetic recording medium.

In accordance with the present invention, a patterned anodized Al oxide layer is formed on a non-magnetic substrate for increased areal recording density. The anodized pattern can be formed on any non-magnetic substrate, and typically exhibits a substantially hexagonal honeycomb structure comprising a single hexagonal unit cell ranging from about 50Å to about 5000Å in diameter and about 50Å to about 10,000Å in depth. Conventional magnetron sputtering techniques can be employed to produce magnetic recording media in accordance with the present invention. Accordingly, the present invention can be easily integrated into existing production facilities. The present invention enables the formation of magnetic recording media suitable for high areal density recording having improved Hr, improved SNR and S*. The present invention also achieves a significant increase in SNR by effecting separation of magnetic grain cells by the pattern boundaries, thereby suppressing magnetic interaction. The present invention enables production of any of various types of magnetic recording media, particularly magnetic recording media, such as thin film disks having improved flying heights.

Only certain embodiments of the present invention and but a few examples of its versatility are shown and described in the present disclosure. It is to be understood that the present invention is capable of use in various other combinations and environments and is capable of changes and modifications within the scope of the inventive concept as expressed herein.

What is claimed is:

1. A magnetic recording medium comprising:

a non-magnetic substrate;

a layer comprising aluminum (Al) or an Al alloy on the substrate, the layer having a substantially uniform pattern thereon; and

a magnetic layer; wherein,

the pattern is substantially replicated on the magnetic layer to form a data zone.

2. The magnetic recording medium according to claim 1, further comprising a laser textured landing zone.

3. The magnetic recording medium according to claim 1, wherein the pattern comprises a substantially honeycomb pattern of aluminum oxide formed by anodization.

4. The magnetic recording medium according to claim 3, wherein the honeycomb pattern comprises substantially hexagonal cells.

5. The magnetic recording medium according to claim 4, wherein the cells have a diameter of about 50Å to about 5000Å and a depth of about 50Å to about 10,000Å.

6. The magnetic recording medium according to claim 1, wherein the Al or Al alloy layer has a thickness of about 50Å to about 5000Å.

7. The magnetic recording medium according to claim 6, wherein the Al or Al alloy layer has a thickness of about 500Å to about 1500Å.

8. The magnetic recording medium according to claim 1, further comprising:

a seedlayer directly on the patterned Al or Al alloy layer;

an underlayer on the seedlayer and;

the magnetic layer on the underlayer.

9. The magnetic recording medium according to claim 8, wherein:

the substrate comprises a nickel phosphorus plated Al or Al alloy;

the seedlayer comprises nickel aluminum;

the underlayer comprises chromium vanadium; and

the magnetic layer comprises a cobalt-chromium-platinum-tantalum alloy.

10. The magnetic recording medium according to claim 1, wherein the substrate comprises nickel-phosphorus plated aluminum or aluminum alloy, or a glass, ceramic or glass-ceramic material.

11. A method of manufacturing a magnetic recording medium, the method comprising:

forming a layer of aluminum (Al) or Al alloy on a non-magnetic substrate;

forming a substantially uniform pattern on the Al or Al alloy layer; and

forming a magnetic layer; wherein,

the pattern is substantially replicated on the magnetic layer to form a data zone.

12. The method according to claim 11, comprising forming the pattern by anodizing the Al or Al alloy layer, wherein the pattern comprises aluminum oxide.

13. The method according to claim 12, comprising anodizing the Al or Al alloy layer to form a substantially honeycomb pattern containing substantially hexagonal cells.

14. The method according to claim 13, wherein the cells have a diameter of about 50Å to about 5000Å and a depth of about 50Å to 10,000Å.

15. The method according to claim 11, comprising sputter depositing the Al or Al alloy layer to a thickness of about 50Å to about 5000Å.

16. The method according to claim 15, comprising sputter depositing the Al or Al alloy to a thickness of about 500Å to about 1500Å.

17. The method according to claim 13, comprising anodizing with a solution comprising about 1% to about 15% hydrogen phosphate for about 1 to about 15 minutes.

18. The method according to claim 11, comprising laser texturing the substrate to form a textured area which is substantially replicated on the magnetic layer to form a landing zone.

19. The method according to claim 11, comprising:

sputtering depositing a seedlayer directly on the patterned Al or Al alloy layer;

sputter depositing an underlayer on the seedlayer; and

sputter depositing a magnetic layer on the underlayer.

20. The method according to claim 19, wherein:

the substrate comprises nickel-phosphorous plated Al or an Al alloy;

the seedlayer comprises nickel aluminum;

the underlayer comprises chromium vanadium; and

the magnetic layer comprises an alloy of cobalt-chromium-platinum-tantalum.

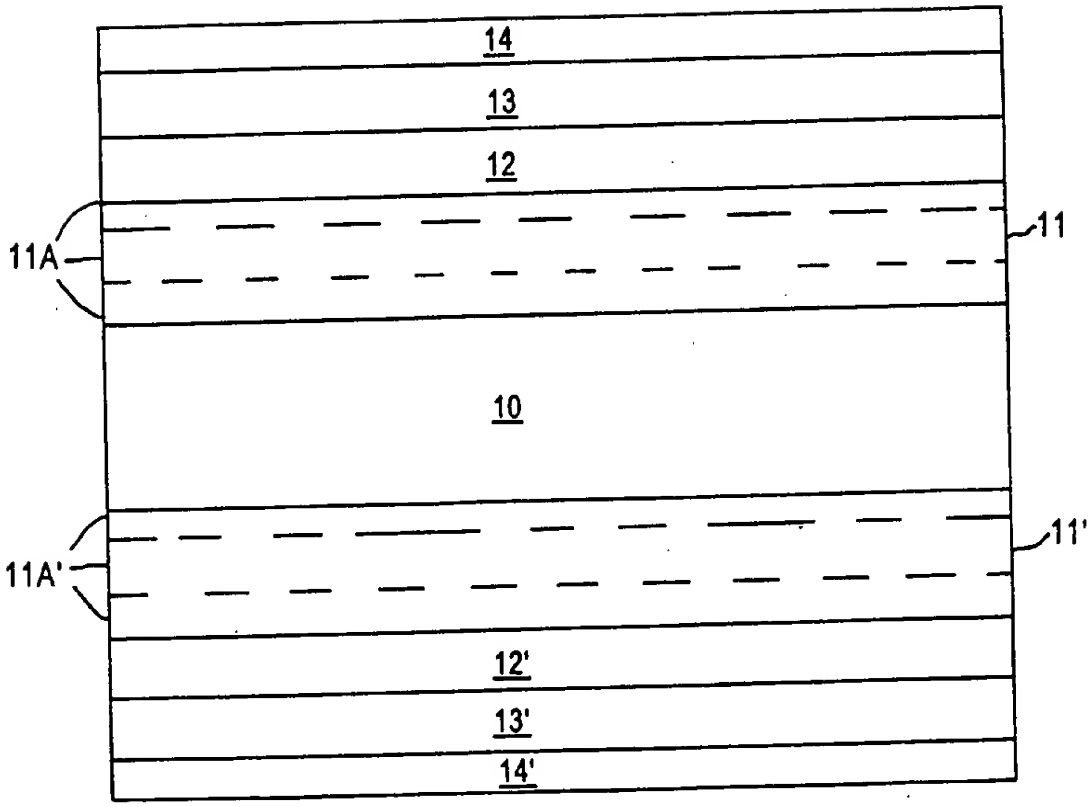


FIG. 1

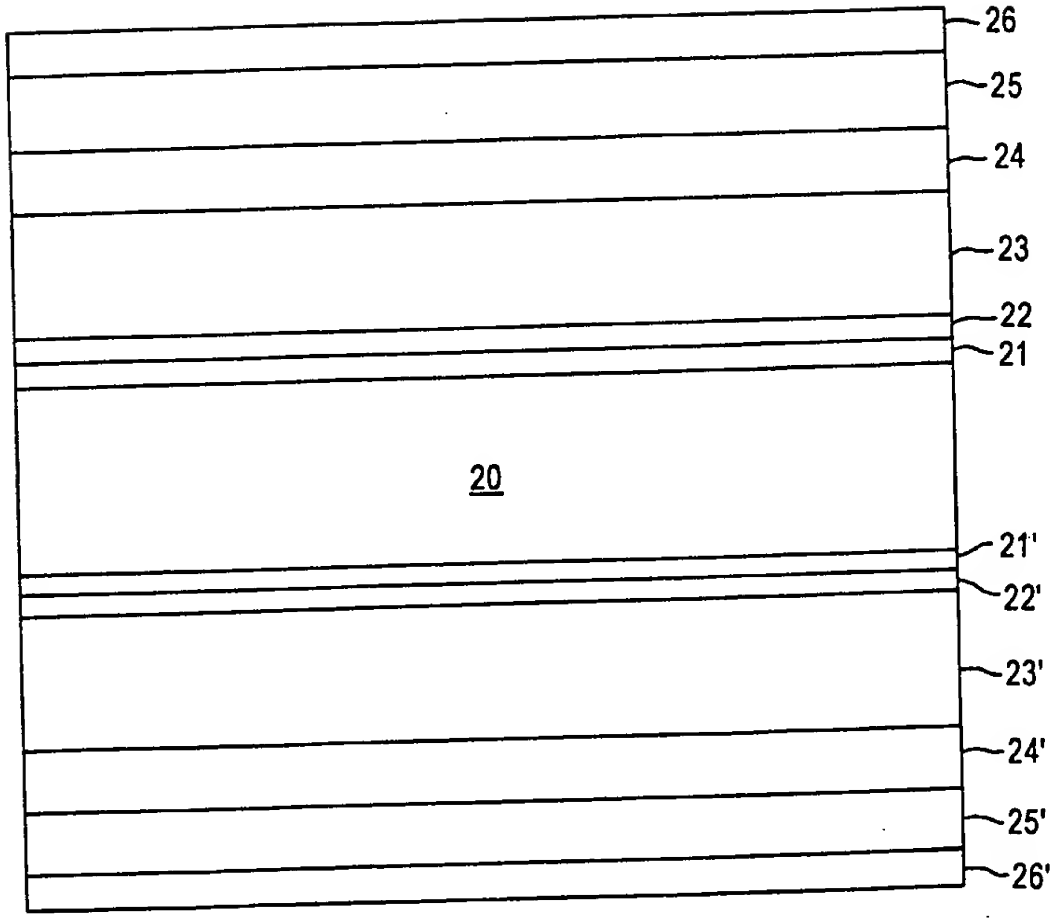


FIG. 2

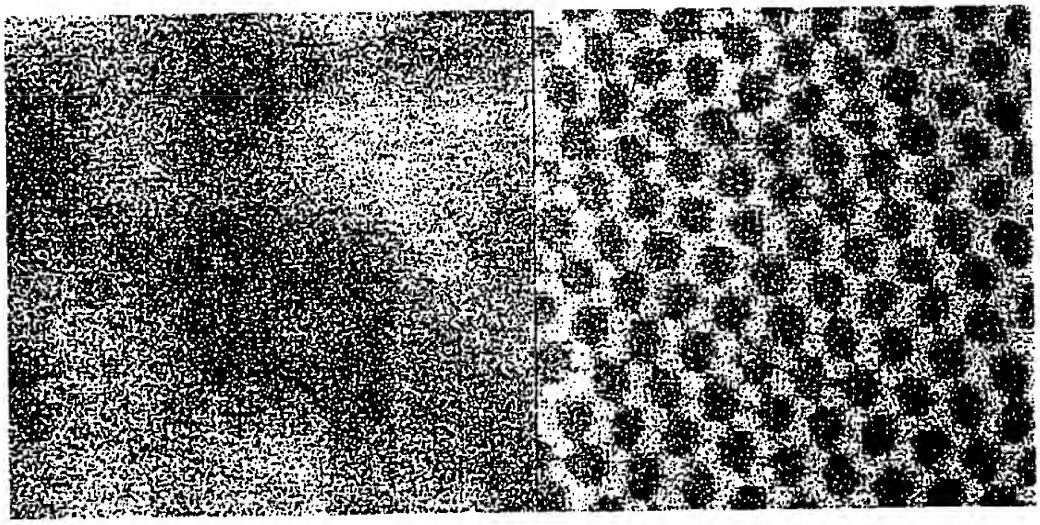
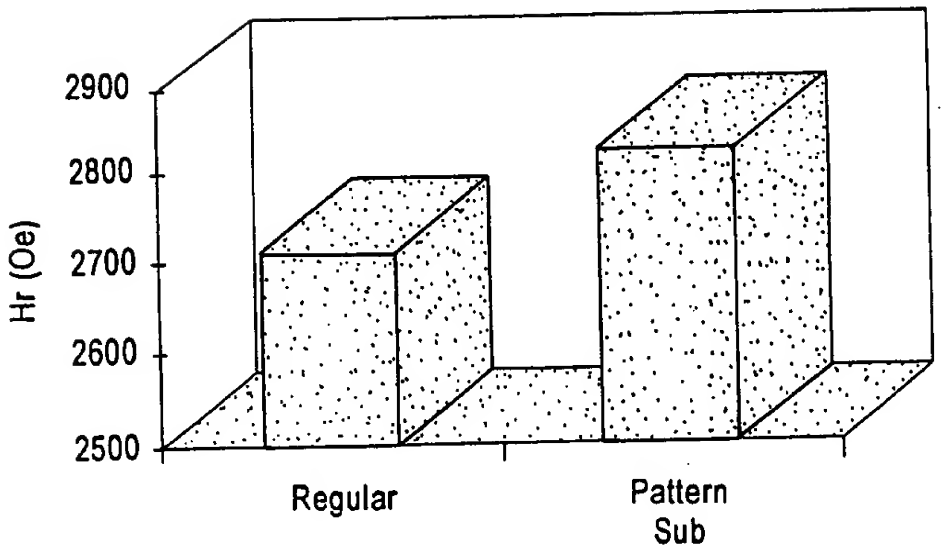


FIG.3

FIG. 4A


2900
2800
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Hr (Oe)
Regular
Pattern
Sub

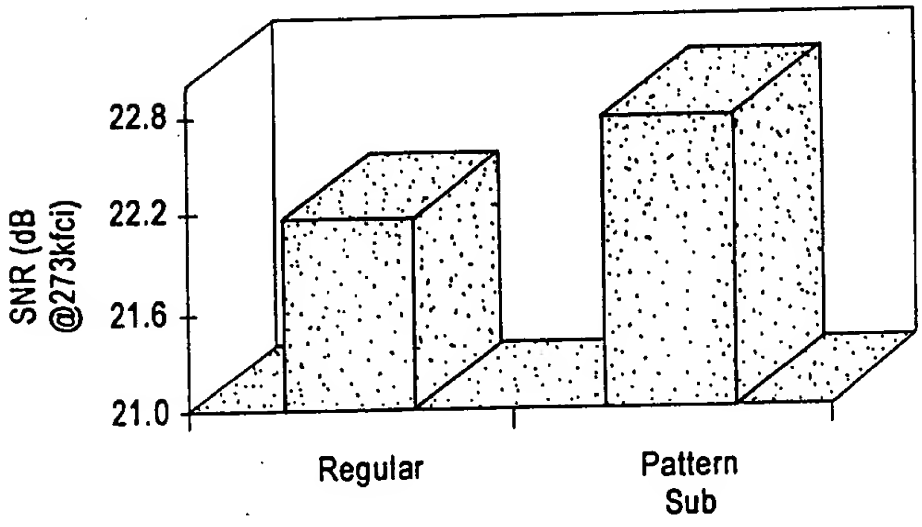
22.8
22.2
21.6
21.0
SNR (dB
@273kfci)
Regular
Pattern
Sub

FIG. 4B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/02670

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G11B 5/66
US CL :428/694R, 694T, 694TS, 694TC, 694TR; 427/127, 130
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 428/694R, 694T, 694TS, 694TC, 694TR; 427/127, 130

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,062,021 A (RANJAN et al.) 29 October 1991, see entire document.	1-20
A,P	US 5,718,811 A (CHEN et al.) 17 February 1998, see entire document.	1-20

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
22 MARCH 1999	14 APR 1999
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer ELIZABETH EVANS
Facsimile No. (703) 305-3230	Telephone No. (703) 308-0661

Form PCT/ISA/210 (second sheet)(July 1992)*

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: ARTHUR J. STEINER
MCDERMOTT, WILL & EMERY
600 13TH STREET, NW
WASHINGTON, DC 20005-3096

PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of Mailing *(day/month/year)*	28 DEC 1999

Applicant's or agent's file reference	IMPORTANT NOTIFICATION
50103-225	

International application No.	International filing date *(day/month/year)*	Priority Date *(day/month/year)*
PCT/US99/02670	10 FEBRUARY 1999	10 FEBRUARY 1998

Applicant
SEAGATE TECHNOLOGY, INC.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	ELIZABETH EVANS
Facsimile No. (703) 305-3230	Telephone No. (703) 308-0661

Form PCT/IPEA/416 (July 1992)★

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 50103-225	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US99/02670	International filing date *(day/month/year)* 10 FEBRUARY 1999	Priority date *(day/month/year)* 10 FEBRUARY 1998
International Patent Classification (IPC) or national classification and IPC IPC(6): G11B 5/66 and US Cl.: 428/694R, 694T, 694TS, 694TC, 694TR; 427/127, 130		
Applicant SEAGATE TECHNOLOGY, INC.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets.

   [X] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 0 sheets.

3. This report contains indications relating to the following items:

   - I [X] Basis of the report
   - II [ ] Priority
   - III [ ] Non-establishment of report with regard to novelty, inventive step or industrial applicability
   - IV [ ] Lack of unity of invention
   - V [X] Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI [ ] Certain documents cited
   - VII [ ] Certain defects in the international application
   - VIII [ ] Certain observations on the international application

Date of submission of the demand	Date of completion of this report
25 AUGUST 1999	18 OCTOBER 1999
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer ELIZABETH EVANS Telephone No. (703) 308-0661

Form PCT/IPEA/409 (cover sheet) (January 1994)*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US99/02670

I. Basis of the report

1. This report has been drawn on the basis of *(Substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments)*:

[X] the international application as originally filed.

[X] the description, pages 1-13 , as originally filed.
pages NONE , filed with the demand.
pages NONE , filed with the letter of _____.
pages _____ , filed with the letter of _____.

[X] the claims, Nos. 1-20 , as originally filed.
Nos. NONE , as amended under Article 19.
Nos. NONE , filed with the demand.
Nos. NONE , filed with the letter of _____.
Nos. _____ , filed with the letter of _____.

[X] the drawings, sheets/~~fig~~ 1-4 , as originally filed.
sheets/~~fig~~ NONE , filed with the demand.
sheets/~~fig~~ NONE , filed with the letter of _____.
sheets/~~fig~~ _____ , filed with the letter of _____.

2. The amendments have resulted in the cancellation of:

[X] the description, pages NONE.

[X] the claims, Nos. NONE.

[X] the drawings, sheets/~~fig~~ NONE.

3. [ ] This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the ~~Supplemental Box~~ Additional observations below (Rule 70.2(c)).

4. Additional observations, if necessary:

NONE

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US99/02670

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. STATEMENT

Novelty (N)	Claims	1-20	YES
	Claims	NONE	NO
Inventive Step (IS)	Claims	1-20	YES
	Claims	NONE	NO
Industrial Applicability (IA)	Claims	1-20	YES
	Claims	NONE	NO

2. CITATIONS AND EXPLANATIONS

Claims 1-20 meet the criteria set out in PCT Article 33(2)-(4), because the prior art does not teach or fairly suggest a magnetic recording medium comprising a non-magnetic substrate, an aluminum or aluminum alloy layer having a uniform pattern thereon, and a magnetic layer having the same pattern thereon where the pattern may be a honeycomb pattern or the method of making the magnetic recording medium. The medium has utility in that it may be used in the recording art.

---------- NEW CITATIONS ----------

NONE

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: GENE Z. RUBINSON
MCDERMOTT, WILL & EMERY
600 13TH STREET, NW
WASHINGTON, DC 20005-3096

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

	Date of Mailing *(day/month/year)* 14 APR 1999
Applicant's or agent's file reference 50103-225	**FOR FURTHER ACTION** **See paragraphs 1 and 4 below**
International application No. PCT/US99/02670	International filing date *(day/month/year)* 10 FEBRUARY 1999
Applicant SEAGATE TECHNOLOGY, INC.	

1. [X] The applicant is hereby notified that the international search report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the international search report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in rules 90 *bis* 1 and 90 *bis* 3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer ELIZABETH EVANS B. Hardaway for
Facsimile No. (703) 305-3230	Telephone No. (703) 308-0661

Form PCT/ISA/220 (January 1994)★ *(See notes on accompanying sheet)*

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 50103-225	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
International application No. PCT/US99/02670	International filing date *(day/month/year)* 10 FEBRUARY 1999	(Earliest) Priority Date *(day/month/year)* 10 FEBRUARY 1998
Applicant SEAGATE TECHNOLOGY, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. [ ] **Certain claims were found unsearchable** (See Box I).

2. [ ] **Unity of invention is lacking** (See Box II).

3. [ ] The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing
   - [ ] filed with the international application.
   - [ ] furnished by the applicant separately from the international application,
     - [ ] but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
   - [ ] transcribed by this Authority.

4. With regard to the **title**,
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,
   - [ ] the text is approved as submitted by the applicant.
   - [X] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is:

   Figure No. 2
   - [ ] as suggested by the applicant.
   - [X] because the applicant failed to suggest a figure.
   - [ ] because this figure better characterizes the invention.
   - [ ] None of the figures.

Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

ABSTRACT

Magnetic recording media exhibiting improved Hr, SNR, and S*, suitable for high areal recording density, are obtained by forming a substantially uniform patterned Al or Al alloy layer (21, 21') on a non-magnetic substrate (20) which is substantially replicated in subsequently applied layers (22, 22', 23, 23', 24, 24', 25, 25', 26, 26') to form a data zone. Embodiments include sputtering depositing an Al or al alloy layer (21, 21') on the substrate (20) and anodizing the sputtered layer (21, 21') to form a plurality of substantially uniform hexagonal cells comprising aluminum oxide. The hexagonal pattern is replicated in a subsequently deposited and epitaxially grown magnetic layer (24, 24') such as that the magnetic grains are separated, therby reducing manetostatic interactions therebetween.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/02670

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G11B 5/66
US CL :428/694R, 694T, 694TS, 694TC, 694TR; 427/127, 130
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 428/694R, 694T, 694TS, 694TC, 694TR; 427/127, 130

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,062,021 A (RANJAN et al.) 29 October 1991, see entire document.	1-20
A,P	US 5,718,811 A (CHEN et al.) 17 February 1998, see entire document.	1-20

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"B"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
22 MARCH 1999	14 APR 1999
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer ELIZABETH EVANS Telephone No. (703) 308-0661

Form PCT/ISA/210 (second sheet)(July 1992)★

HOME COPY

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

Receiving Office use only

PCT/US 99 / 02670
International Application No.

(10-02-99)
International Filing Date 10 FEB 1999

...ONAL
.../US
Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* 50103-225

Box No. I TITLE OF INVENTION

MAGNETIC RECORDING MEDIUM WITH PATTERNED SUBSTRATE

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

SEAGATE TECHNOLOGY, INC.
920 Disc Drive
P.O. Box 66360
Scotts Valley, CA 95067-0360
US

☐ This person is also inventor.

Telephone No.

Facsimile No.

Teleprinter No.

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

WU, Zhong (Stella)
45130 Pawnee Drive
Fremont, CA 94539
US

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: CN

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

RUBINSON, Gene Z.
McDermott, Will & Emery
600 13th Street, NW
Washington, DC 20005-3096
US

Telephone No. 202-756-8000

Facsimile No. 202-756-8087

Teleprinter No.

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Sheet No. . . . 2 . . .

Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet is not to be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

RANJAN, Rajiv
6620 Creekview Court
San Jose, CA 95120
US

This person is:

- [ ] applicant only
- [x] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: IN

State *(that is, country)* of residence: US

This person is applicant for the purposes of: [ ] all designated States [ ] all designated States except the United States of America [x] the United States of America only [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:

- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: [ ] all designated States [ ] all designated States except the United States of America [ ] the United States of America only [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:

- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: [ ] all designated States [ ] all designated States except the United States of America [ ] the United States of America only [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:

- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: [ ] all designated States [ ] all designated States except the United States of America [ ] the United States of America only [ ] the States indicated in the Supplemental Box

[ ] Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked):*

Regional Patent

☐ **AP ARIPO Patent:** **GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **SD** Sudan, **SZ** Swaziland, UG Uganda, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

☐ **EA Eurasian Patent:** **AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakhstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☐ **EP European Patent:** **AT** Austria, **BE** Belgium, **CH and LI** Switzerland and Liechtenstein, **CY** Cyprus, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **SE** Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☐ **OA OAPI Patent:** **BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Côte d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line):*

☐ **AL** Albania .....
☐ **AM** Armenia .....
☐ **AT** Austria .....
☐ **AU** Australia .....
☐ **AZ** Azerbaijan
☐ **BA** Bosnia and Herzegovina .....
☐ **BB** Barbados
☐ **BG** Bulgaria .....
☐ **BR** Brazil .....
☐ **BY** Belarus
☐ **CA** Canada
☐ **CH and LI** Switzerland and Liechtenstein
☐ **CN** China .....
☐ **CU** Cuba .....
☐ **CZ** Czech Republic .....
☒ **DE** Germany .....
☐ **DK** Denmark .....
☐ **EE** Estonia .....
☐ **ES** Spain .....
☐ **FI** Finland .....
☒ **GB** United Kingdom
☐ **GE** Georgia .....
☐ **GH** Ghana .....
☐ **GM** Gambia
☐ **GW** Guinea-Bissau .....
☐ **HR** Croatia
☐ **HU** Hungary .....
☐ **ID** Indonesia
☐ **IL** Israel .....
☐ **IS** Iceland
☒ **JP** Japan .....
☐ **KE** Kenya .....
☐ **KG** Kyrgyzstan .....
☐ **KP** Democratic People's Republic of Korea .....
.....
☒ **KR** Republic of Korea .....
☐ **KZ** Kazakhstan .....
☐ **LC** Saint Lucia
☐ **LK** Sri Lanka
☐ **LR** Liberia
☐ **LS** Lesotho .....
☐ **LT** Lithuania
☐ **LU** Luxembourg
☐ **LV** Latvia
☐ **MD** Republic of Moldova .....
☐ **MG** Madagascar .....
☐ **MK** The former Yugoslav Republic of Macedonia .....
.....
☐ **MN** Mongolia
☐ **MW** Malawi .....
☐ **MX** Mexico .....
☐ **NO** Norway
☐ **NZ** New Zealand .....
☐ **PL** Poland .....
☐ **PT** Portugal .....
☐ **RO** Romania
☐ **RU** Russian Federation .....
☐ **SD** Sudan
☐ **SE** Sweden
☒ **SG** Singapore
☐ **SI** Slovenia .....
☐ **SK** Slovakia .....
☐ **SL** Sierra Leone
☐ **TJ** Tajikistan .....
☐ **TM** Turkmenistan .....
☐ **TR** Turkey .....
☐ **TT** Trinidad and Tobago .....
☐ **UA** Ukraine .....
☐ **UG** Uganda .....
☒ **US** United States of America .....
.....
☐ **UZ** Uzbekistan .....
☐ **VN** Viet Nam .....
☐ **YU** Yugoslavia .....
☐ **ZW** Zimbabwe .....

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

☐ .....
☐ .....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

Supplemental Box *If the Supplemental Box is not used, this sheet need not be included in the request.*

*1. If, in any of the Boxes, **the space is insufficient** to furnish all the information: in such case, write "Continuation of Box No. ..." [indicate the number of the Box] and furnish the information in the same manner as required according to the captions of the Box in which the space was insufficient, in particular:*

*(i) **if more than two persons are involved as applicants and/or inventors** and no "continuation sheet" is available: in such case, write "Continuation of Box No. III" and indicate for each additional person the same type of information as required in Box No. III. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below;*

*(ii) if, in Box No. II or in any of the sub-boxes of Box No. III, the indication **"the States indicated in the Supplemental Box"** is checked: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the applicant(s) involved and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is applicant;*

*(iii) if, in Box No. II or in any of the sub-boxes of Box No. III, **the inventor or the inventor/applicant is not inventor for the purposes of all designated States or for the purposes of the United States of America:** in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the inventor(s) and, next to (each) name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is inventor;*

*(iv) if, in addition to the agent(s) indicated in Box IV, there are **further agents**: in such case, write "Continuation of Box No. IV" and indicate for each further agent the same type of information as required in Box No. IV:*

*(v) if, in Box No. V, the name of any State (or OAPI) is accompanied by the indication **"patent of addition,"** or **"certificate of addition,"** or if, in Box No. V., the name of the United States of America is accompanied by an indication **"continuation"** or **"continuation-in-part"**: in such case, write "Continuation of Box No. V" and the name of each State involved (or OAPI), and after the name of each such State (or OAPI) , the number of the parent title or parent application and the date of grant of the parent title or filing of the parent application;*

*(vi) if, in Box No. VI, there are **more than three earlier applications whose priority is claimed:** in such case, write "Continuation of Box No. VI" and indicate for each additional earlier application the same type of information as required in Box No. VI;*

*(vii) if, in Box No. VI, the **earlier application is an ARIPO application:** in such case, write "Continuation of Box No. VI", specify the number of the item corresponding to that earlier application and indicate at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed.*

*2. If, with regard to the **precautionary designation statement** contained in Box No. V, the applicant wishes to exclude any State(s) from the scope of that statement: in such case, write "Designation(s) excluded from precautionary designation statement" and indicate the name or two-letter code of each State so excluded.*

*3. If the applicant claims, in respect of any designated Office, the benefits of provisions of the national law concerning **non-prejudicial disclosures or exceptions to lack of novelty**: in such case, write "Statement concerning non-prejudical disclosures or exceptions to lack of novelty" and furnish that statement below.*

Continuation of Box No. IV:

The following agents are additionally appointed to act on behalf of applicant(s) before the competent International Authorities:

Becker, Edward A.; Becker, Stephen A.; Bingham, Marcel K.; Bisbikis, John G.; Cage, Kenneth L.; Carlson, Stephen C.; Devinsky, Paul; Donnelly, Laura A.; Duncan, Margaret M.; Ferguson, Brian E.; Fogarty, Michael F.; Gadiano, Wilhelm F.; George, Keith E.; Hankins, John A.; Hickman, Brian D.; Jolly, Thomas A.; Kraus, Eric J.; Kubasiewicz, Edward E.; Law, Patrick B.; LeBlanc, Robert E.; Lever, Jack Q.; Lupo, Raphael V.; Martin, Christine F.; McCabe, Jr., Michael E.; Meadows, James H.; Messina, Michael; Molinelli, Eugene J.; Palermo, Christopher J.; Paquin, Jr., Joseph H.; Plastrik, Craig L.; Price, Robert L..; Roberts, Paul A.; Rubinson, Gene Z.; Serauskas, Joy Ann G.; Schafer, Michele M.; Serbin, David J.; Snyder, Glenn; Steiner, Arthur J.; Stewart, David L.; Thenor, Leonid D.; Turkevich, Leon R.; Ward, Christopher D.; Wasserbauer, Damian G.; Wise, Edward J.; and, Zelnick, Robert W.; all members of the bar.

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) 10 February 1998 (10-02-98)	60/074,253	US		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s): (1)

** Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):*

ISA/ US

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority):*

Date *(day/month/year)* Number Country (or regional Office)

Box No. VIII CHECK LIST: LANGUAGE OF FILING

This international application contains the following **number of sheets:**

request	:	5
description (excluding sequence listing part)	:	13
claims	:	3
abstract	:	1
drawings	:	4
sequence listing part of description	:	
Total number of sheets	:	26

This international application is **accompanied** by the item(s) marked below:

1. ☒ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as items(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☒ other *(specify)*: Transmittal Letter (1 sheet)

Figure of the drawings which should accompany the abstract:

Language of filing of the international application:

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

Gene Z. Rubinson

Gene Z. Rubinson (10-02-99)

For receiving Office use only

1. Date of actual receipt of the purported international application: 14 Rec'd PCT/PTO 1 5 FEB 1999
2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority (if two or more are competent): ISA/US
6. ☐ Transmittal of search copy delayed until search fee is paid

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

RUBINSON, Gene, Z.
McDermott, Will & Emery
600 13th Sreet, N.W.
Washington, DC 20005-3096
ETATS-UNIS D'AMERIQUE

Date of mailing (day/month/year)
10 August 2000 (10.08.00)

Applicant's or agent's file reference
50103-225

IMPORTANT NOTIFICATION

International application No.
PCT/US99/02670

International filing date (day/month/year)
10 February 1999 (10.02.99)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address
SEAGATE TECHNOLOGY, INC.
920 Disc Drive
P.O. Box 66360
Scotts Valley, CA 95067-0360
United States of America

State of Nationality: US
State of Residence: US
Telephone No.:
Facsimile No.:
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [X] the name [ ] the address [ ] the nationality [ ] the residence

Name and Address
SEAGATE TECHNOLOGY LLC
920 Disc Drive
P.O. Box 66360
Scotts Valley, CA 95067-0360
United States of America

State of Nationality:
State of Residence:
Telephone No.:
Facsimile No.:
Teleprinter No.:

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

Authorized officer
Peggy Steunenberg
Telephone No.: (41-22) 338.83.38